Segment-to-segment method

Master faces in contact are decomposed using the contours of slave faces, which are projected onto master faces based on master faces normals. The penetration of master and slave faces is calculated by integrating the penetration distance between a master and slave face, in the master normal direction. The normal contact forces at face centres are calculated using penalty method and average value of the calculated penetration. In the proposed procedure, the penetration is calculated for master and slave faces simultaneously, which eliminates the need for normal contact force interpolation, i.e. the contact force is calculated separately on both contact patches.

Summary

A segment-to-segment algorithm for normal contact force calculation is proposed for finite volume based mechanical contact simulations. The proposed algorithm calculates contact force using an integral value of the penetration, which should improve the overall accuracy of the numerical model. The inspiration for such an approach is based on the segment-to-segment contact formulation commonly used in the finite element contact algorithms. The implementation allows calculation of mechanical contact on arbitrary unstructured meshes and with large deformation of contacted bodies. The proposed contact algorithm was tested on contact benchmarks that include large deformations and contact with large sliding.

Introduction

Despite the finite element method being commonly used in the area of computational contact mechanics, the recent developments of the finite volume method in the field of computational solid mechanics makes it good candidate for solving complex contact mechanics problems.

The existing finite volume mechanical contact calculation algorithm presented in Cardiff et al. (2017) is similar to a node-to-segment finite element algorithm. It is based on the calculation of contact forces at the vertices of the discretized slave contact surfaces, whereas the contact force on the master contact surface is obtained using General Grid Interface interpolation. In the proposed segment-to-segment algorithm normal contact force is calculated using the integral value of penetration. The idea for such an approach is inspired by the segment-to-segment method usually applied in finite element contact calculation algorithms, where contact constraints are satisfied at integration points of the contact elements. The Neumann boundary condition is used on both contact surfaces and contact constraints are enforced using explicitly calculated contact force, which is updated within the segregated solution framework. The presented contact algorithm is implemented in the foam-extend open source library as an extension to the work previously published in Cardiff et al. (2012, 2017).

Numerical examples

The proposed contact algorithm is tested on a series of typical examples. The inertia of the contacting bodies is omitted and a compressible Neo-Hookean material model is used. All examples are solved with a quasi-static approach. At the contact interface, frictionless contact is prescribed.